

# Proposed Megha-Tropiques

## Validation Plan

B Simon

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## Scientific Objective :



- Improve the knowledge of the water cycle in the inter-tropical region- Evaluate the consequence on the energy budget
- To Study the life cycle of tropical convective systems over Oceans & continents, the environmental conditions for their appearance and evolution, their water budget, and associated transports of water vapour

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To understand this we require simultaneous and frequent measurement of Rainfall, water vapor, liquid water, ice, humidity profile, surface winds and radiative fluxes

## The primary parameters from MT are:

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- Related to Water Cycle: Integrated water vapor, *cloud liquid water content*, wind speed, precipitation, humidity profile, temperature profile
- Related Radiation Budget: Short wave and Long wave radiation.

# Validation strategy

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- Validation of Megha - Tropiques Geophysical data products (in-situ)
  - Inter-comparison of MT derived parameters with those by other satellites
  - Comparison of satellite derived products with model analysis
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- Comparisons with data and products from other airborne and space borne sensors, and interaction with established data networks
  - Analysis of trends in atmosphere data products in months /seasons.
  - Participation in community field campaigns (similar to ARMEX, BOBMEX, AMMA, Ship cruises/ radiosondes)
  - Comparison with high resolution model analysis
  - Collaboration with a worldwide effort to derive column precipitable water from a network of surface GPS receivers

# MT & Characteristics

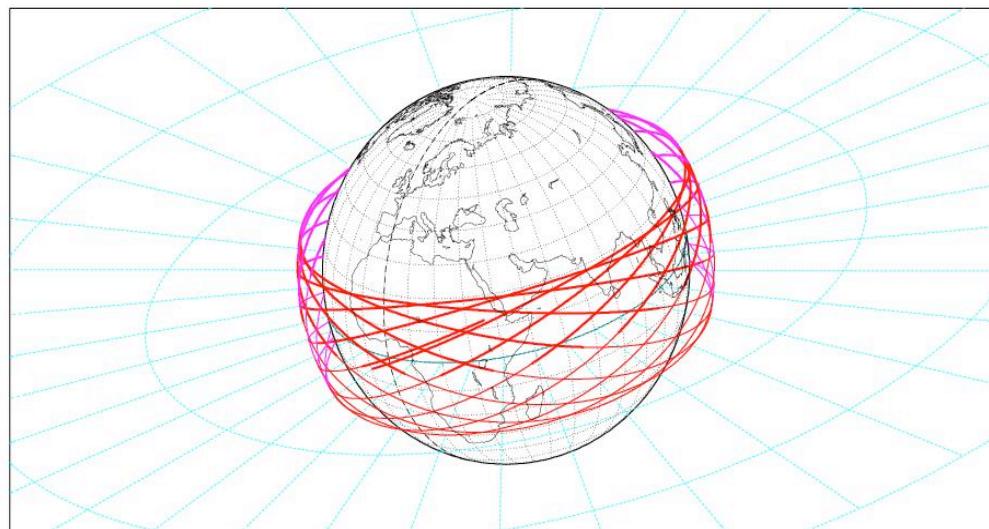
## Megha-Tropiques

Orbit - ref.: Earth

Recurrence = [14; -1; 7] 97

>>> Time span shown: 1440.0 min = 1.00 day

Altitude = 865.6 km       $a = 7243.700 \text{ km}$   
 Inclination = 20.00 °  
 Period = 101.93 min \* rev/day = 14.13  
 Equat. orbital shift = 2892.0 km ( 26.0 °)



Projection: Orthographic

Property: none

T.:Azimuthal  $\oplus$  Graticule: 10°

Map centre: 26.0 ° N: 46.0 ° E

Aspect: Oblique

[ -78.0 / +64.0 / +44.0 ] Gr.Mod.: GRIM5-C1

Asc. node: 0.00 °

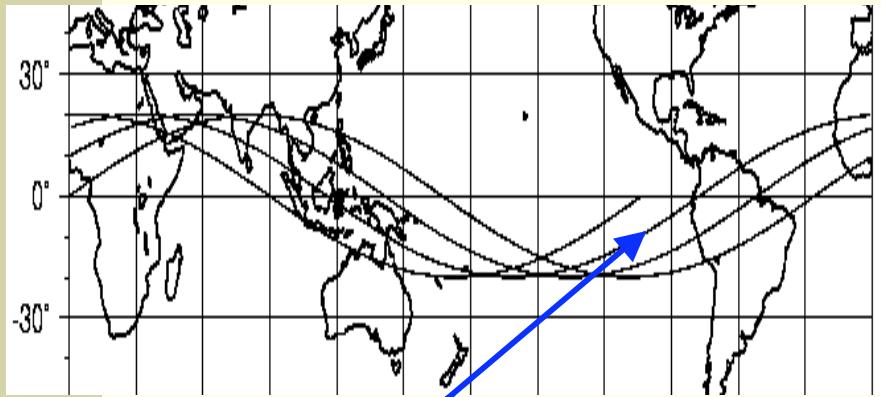
*Iξιων*  
MC ★ LMD  
*Ατλας*

Altitude	866km
Inclination	20 Deg
MADRAS	1740 Km
SAPHIR	1700 Km
ScaRaB	2216 km
Orbital Period	101.93 min (14.13 rev/day)

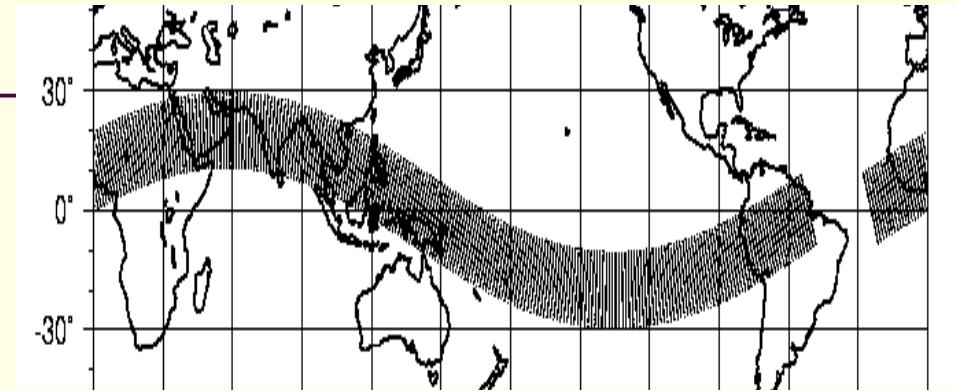
*MeghaTropiques One-day coverage*

Integrated GPS Occultation  
Receiver [IGOR]

## MT & Characteristics

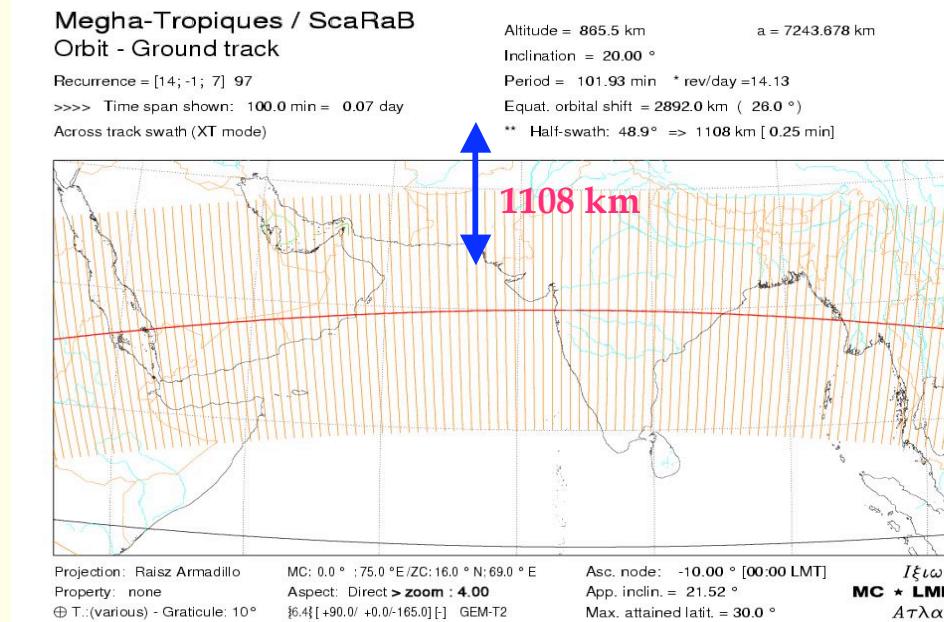


**Equatorial  
orbital shift  
2892.0 km**



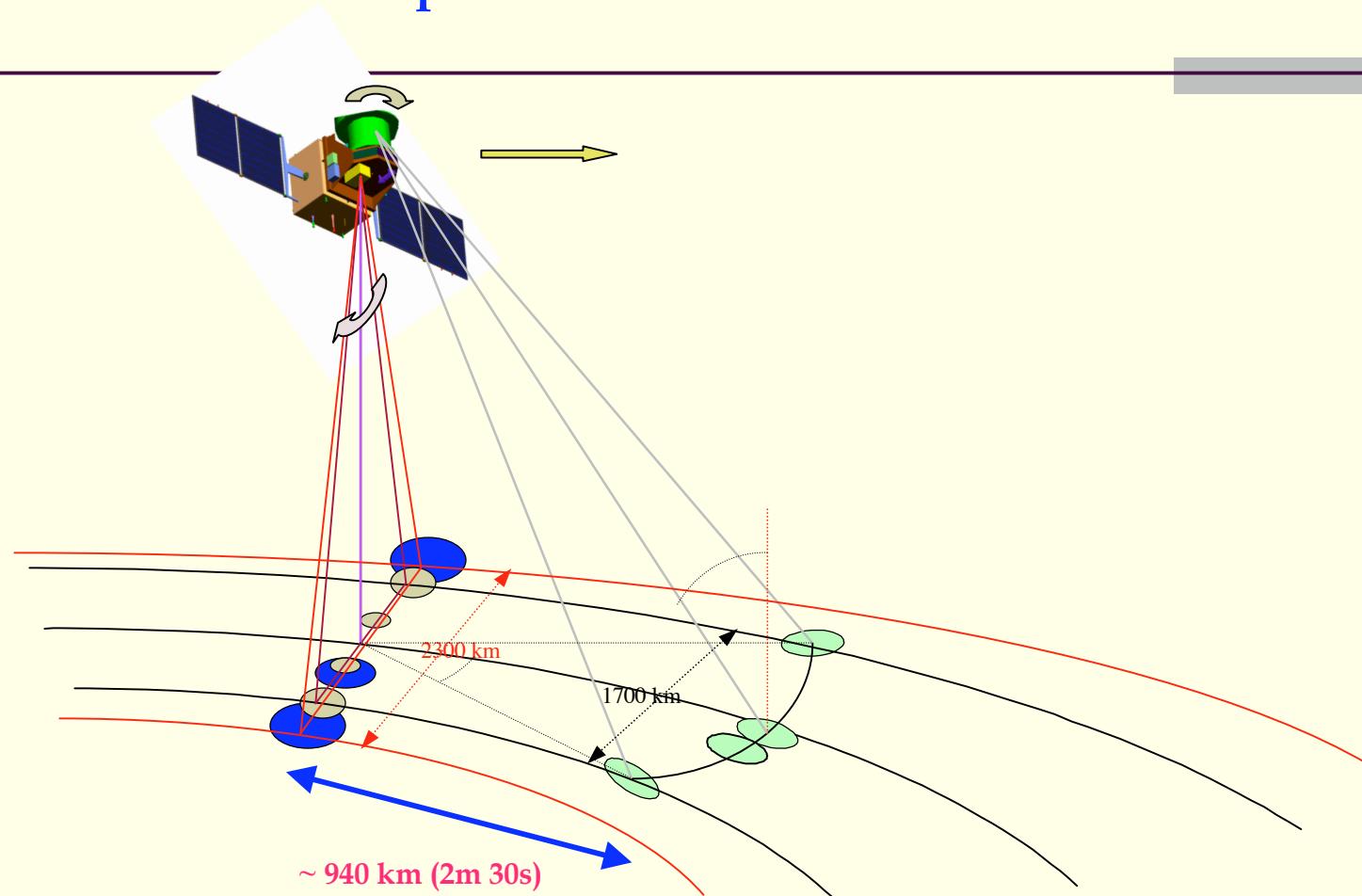
*3-Orbits of MT*

*Swath of One Orbit*



## *MT & Characteristics*

### Foot-prints of the 3 MT instruments



■ SAPHIR

■ ScaRaB

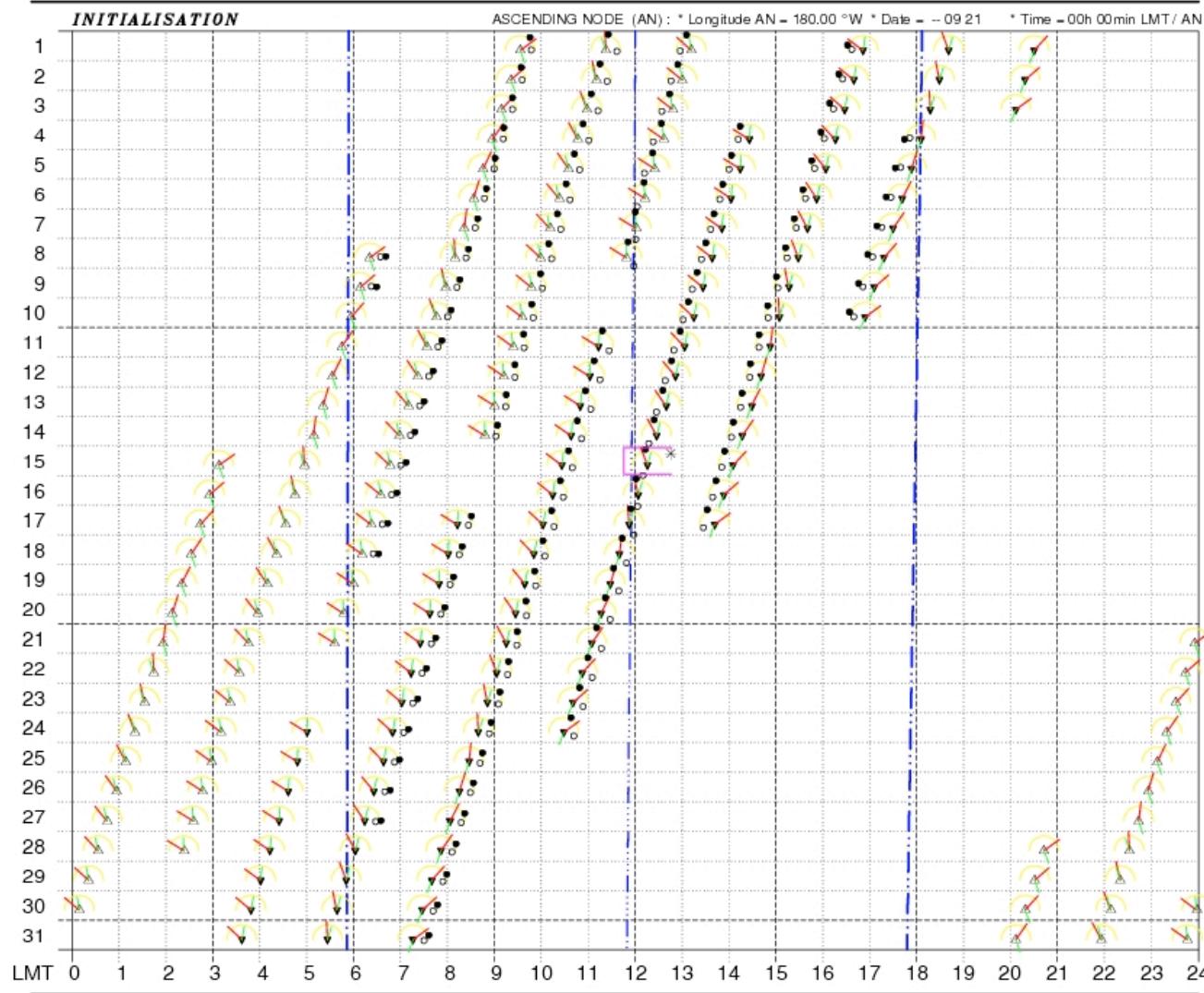
■ MADRAS

Recurrence cycle = 7 days [14; -1; 7] 97  
 Precession cycle = 51 days (Cs = -51.3)  
 \* J=1 (Yr Mn Dy)\* [T] = 09 01\* [S] = 09 01

## Megha-Tropiques

**SEP**

10 ° N  
**MONTHLY  
TABLE**



\* \* \* \* Sunglint [Zen: 15 / Azi: 15]

OVERPASSES (n = 192)  
 OF SATELLITE S [GEM-T2]  
 FOR POINT P  
 - Latitude : 10.0 ° N  
 - Longitude : 0.0 °  
 For P: UTC = LMT + 00h 00m

FIELD OF VIEW : 97.8 °

(1)	P-S DIRECTION
(2)	ASC DES
△	ASC
▼	DES
Right-handed system	
- Zenith angle (in plane orthog. to track).	(1)
- Azimuth (in local horiz. plane) / North.	(2)
SUN	
●	Zen.
○	Azi.

**ORBIT** a = 7243.678 km

Altitude = 865.5 km  
 Inclination = 20.0 °  
 Equatorial shift = 2892.0 km  
 Period = 101.93 min  
 Mean mot. = 14.13 rev/day

**SCANNING**

Half-swath = 48.9 °  
 Maximal zenith angle = 58.9 °  
 H.-swath (ground) = 1108.2 km  
 Equatorial overlap = 2.089  
 Max. attained latit. = 30.0 °

Iξιων  
**MC ★ LMD**

# *MT & Characteristics*

MT, 867 km,  $i=20^\circ$

Instrument	Swath (km)	Size FOV (km)	
		Nadir(0-30°)	Oblique
MADRAS 18.7 to 157 GHz	1740	40 (18-23-36) 10 (89) 6 (157)	
SAPHIR 183 GHz	1700	10 Ø	23x15
ScaRaB SW LW	2216	40 (side)	107

*MADRAS, conical scanning ( $45^\circ$ ), nadir-oblique difference ~940 km, (2 mn 30)*

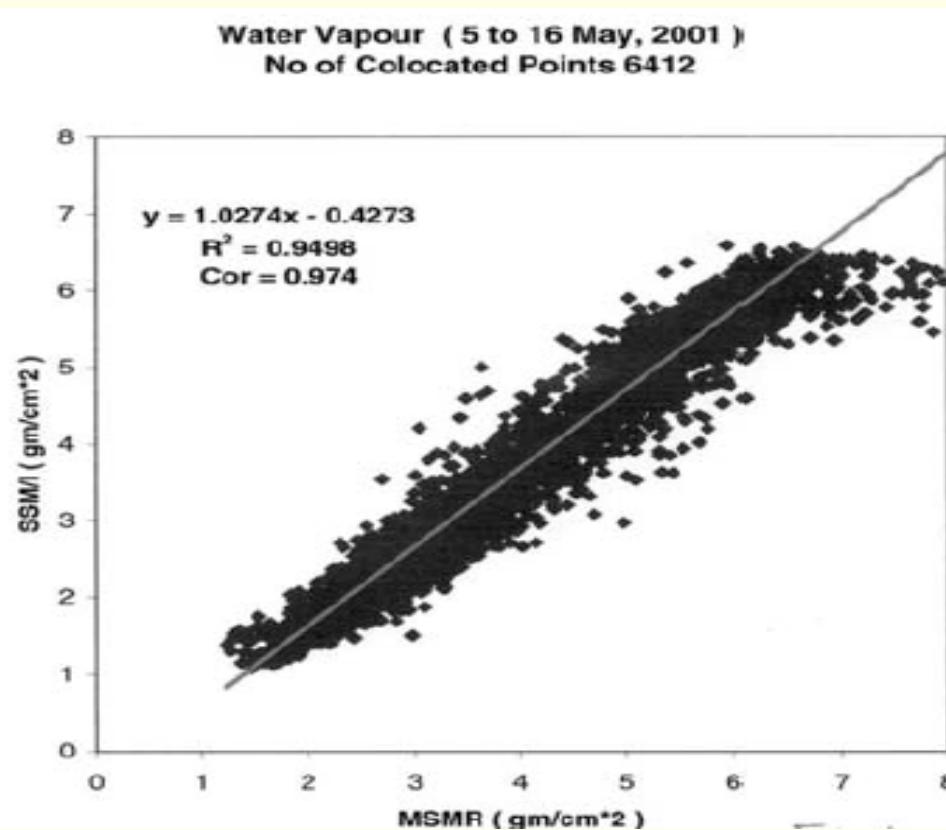
# Experience of validating MSMR products

## Geophysical Parameters from MSMR

Satellite	MSMR
Altitude	720 km
Swath	1360 km
Repetivity	2 days
Orbit inclination	98°
Weight	65 kg
Frequency	6.6, 10.6, 18 , 21 GHz
Polarization	V & H
Spatial Resolution	40 to 120 km
Temperature Resolution	1 °K

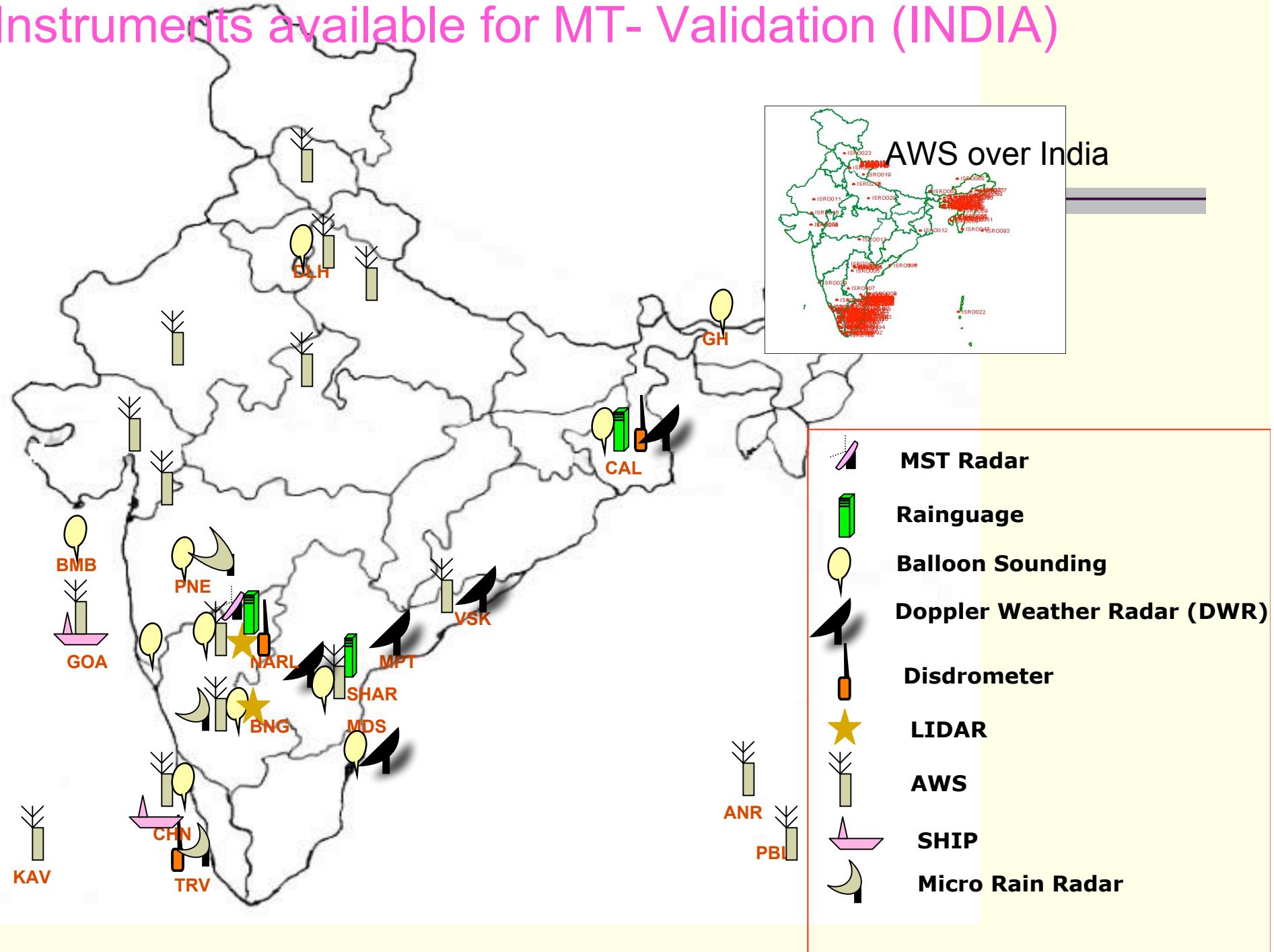
Parameters	Channels	Grids (km)	Range
Total Water Vapour	21 + 18, 10	50	0.2 to 7.5 g/cm2
Sea Surface Wind	10 + 6, 18, 21	75	2-24 m/s
Sea Surface Temperature	6 + 10, 18, 21	150	273 -303 ° K
Cloud Liquid Water	21 + 18, 10	50	0-80 mg/cm2

# Experience of validating MSMR products



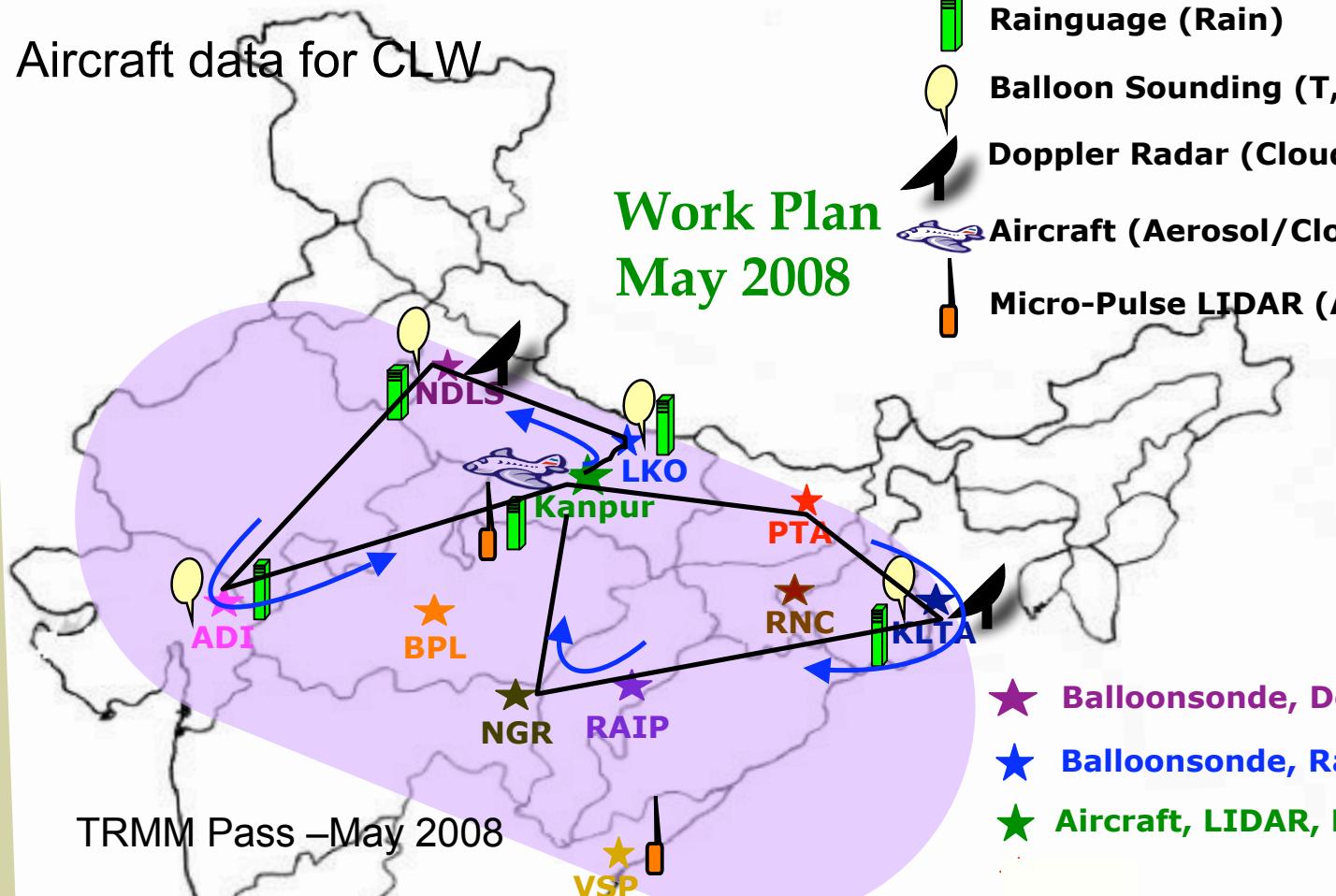
SOURCE	SST (°K)	WS (m/s)	WV (g/cm <sup>2</sup> )
In situ	1.3	1.8	0.4
NCMRWF	-	2.0	0.6
NCEP	0.9	2.1	0.6
SSMI	0.9	2.4	0.5
TMI	1.5	2.0	0.4

# Instruments available for MT- Validation (INDIA)



Aircraft data for CLW

## Work Plan May 2008



Rainguage (Rain)

Balloon Sounding (T, RH)

Doppler Radar (Cloud, ppt, wind)

Aircraft (Aerosol/Cloud microphysics, T, RH)

Micro-Pulse LIDAR (Aerosol/cloud)

★ Balloonsonde, Doppler Radar, Rainguage

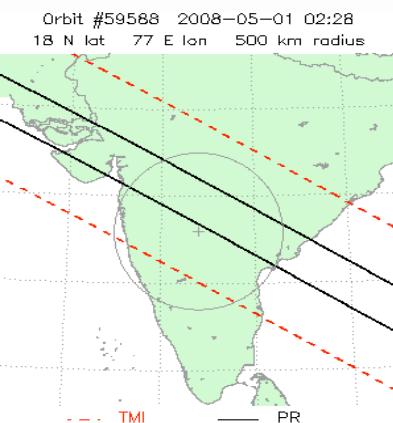
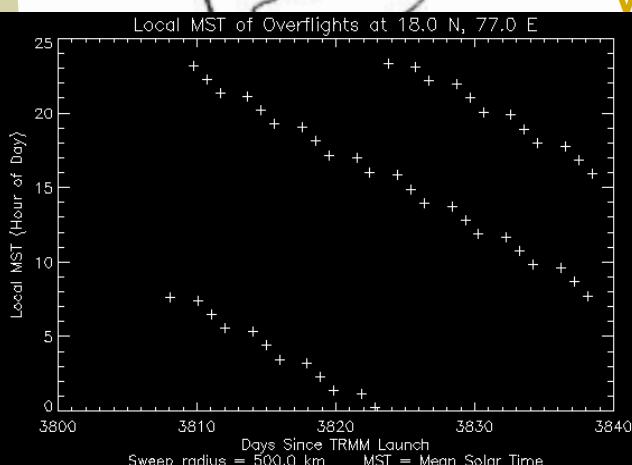
★ Balloonsonde, Rainguage

★ Aircraft, LIDAR, Rainguage

★ Doppler Radar, Ballonsonde, Rainguage

★ Balloonsonde, Rainguage

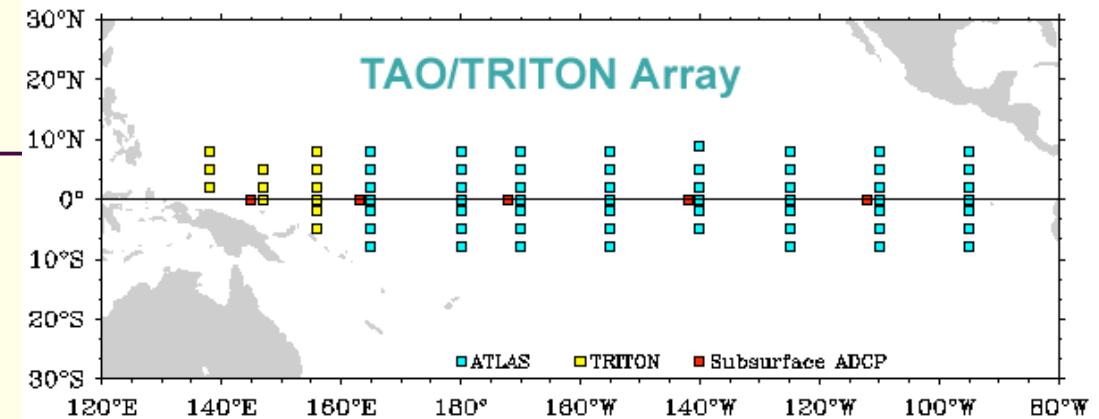
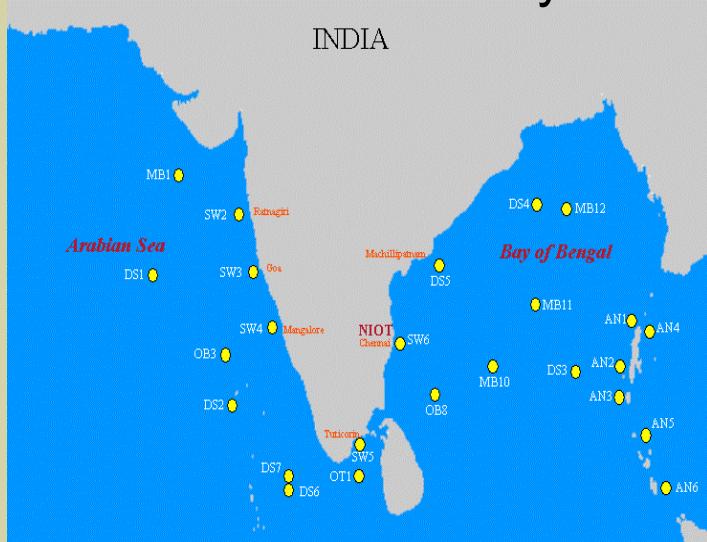
★ LIDAR



# Instruments available for MT validation

<b>Instruments</b>	<b>Relevant Parameter measured</b>	<b>Institutes</b>
C/X/Ka- band radar	Rain Rate	IMD, NARL, ISRO, IISc, CU
Rain guage/ Rain recorder	Rain Rate, rainfall	-do-
Automatic Weather Stations	Surface Humidity, rainfall, surface	IMD, ISRO, NIO, IISc
Radiosonde/ GPS radiosonde.	Temperature and humidity profiles	IISc, Navy, IMD, NARL
Surface Met observations	Surface Humidity, rainfall, surface	IMD
Buoys	Temperature, humidity, wind, Rainfall	NIOT, ISRO, TAO, TRITON
GPS receiver	Temperature and humidity profiles	IMD
Lidars	Cloud	DOS, IMD, IITM
Eppley/ Kipp & Zonen radiation	Radiation	IMD,
Microwave radiometer	Temp , humidity profile	AMMA Sites, NARL
Instrumented aircraft* (platform)	Various Sensors for CLW & cloud characterisaton	NRSA, Manned by French in W. Africa (AMMA Sites)
* to be discussed with French		

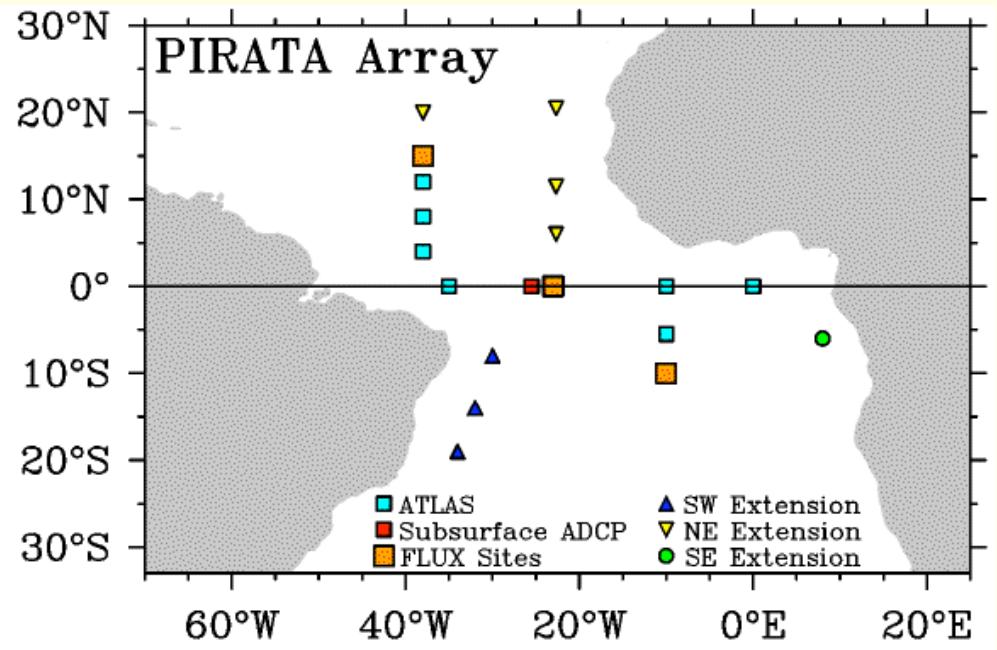
## Data Buoy's Locations for MT- Validation



Present NIOT Buoy Network



TAO Buoy Locations in Pacific Ocean



Pirata Buoy Array Locations in Atlantic Ocean

Institutes	Present Instruments	Future Plans	Proposal in MT
Calcutta University	<ul style="list-style-type: none"> <li>-Optical Raingauge</li> <li>-Disdrometer</li> <li>-Rain attenuation and depolarization at 11 GHz</li> </ul>	<ul style="list-style-type: none"> <li>- Dual frequency radiometer at Darjeeling</li> </ul>	<ul style="list-style-type: none"> <li>-micro rain radar (MRR)</li> <li>-Optical disdrometer(2 nos)</li> </ul>
SHAR	<ul style="list-style-type: none"> <li>-5 ISRO AWS</li> <li>-3 surface observatories</li> <li>-DWR</li> <li>-8 raingauge</li> <li>-100, 50 and 20 meter tower</li> <li>-GPS sonde</li> </ul>	<ul style="list-style-type: none"> <li>-wind profiler</li> <li>-micro rain radar</li> </ul>	
IISc (Bangalore)	<ul style="list-style-type: none"> <li>-GPS Sonde</li> <li>-AWS</li> <li>-Micro Rain Radar</li> <li>-Lidar</li> </ul>		
IMD	<ul style="list-style-type: none"> <li>-Surface Met. Data</li> <li>-5 GPS sonde (Delhi, Bombay, Chennai, Gauhati, Calcutta)</li> <li>-1 X 1 deg rain data</li> <li>-5 DWR (Calcutta, Chennai, SHAR, Visakhapatnam, Muchlipatnam)</li> <li>-110 IMD AWS</li> </ul>		

Institutes	Present Instruments	Future Plans	Proposal in MT
NCAOR, Goa	<ul style="list-style-type: none"> <li>- Sagar Kanya with onboard AWS (2 ship cruises one in summer and one in winter planned – each of 30 days duration)</li> <li>-Surface Met Observation.</li> <li>-NARL can give GPS radiosonde (during IOP'S if needed)</li> </ul>	<p>Within 2 years procurement of one more ship</p> <p>-Vaisala onboard.</p>	
NARL Gadanki	<ul style="list-style-type: none"> <li>-MST Radar</li> <li>-Lower atmospheric wind profiler</li> <li>-LIDAR (2 nos.)</li> <li>-Disdrometer</li> <li>-Optical raingauge</li> <li>-ISRO AWS</li> <li>-GPS sonde at 12 GMT</li> <li>-50 mt tower</li> <li>-sun photometer</li> </ul>	<ul style="list-style-type: none"> <li>-Ka Band Cloud radar (35 GHz)-within 3 years</li> <li>-Dual frequency GPS receiver</li> <li>-LAWP (1 No.)</li> </ul>	<ul style="list-style-type: none"> <li>-18 to 22 GHz vertically looking radiometer</li> <li>--4 disdrometer</li> <li>--10 AWS</li> </ul>
CESS, Trivandrum	<ul style="list-style-type: none"> <li>-Disdrometer</li> <li>-Micro rain radar</li> <li>-Ceilometer</li> <li>-Condensation Nuclei Counter</li> <li>-Liquid water content probe</li> </ul>	<ul style="list-style-type: none"> <li>-Cloud Droplet Spectrometer</li> <li>-CCN Counter</li> </ul>	<ul style="list-style-type: none"> <li>-Ceilometer</li> <li>-Disdrometer</li> </ul>
NIO, Goa	<ul style="list-style-type: none"> <li>-3 NIO AWS (Kavarati, Portblair, Andhrod) (No raingauge)</li> <li>-Coastal vessel</li> </ul>	<ul style="list-style-type: none"> <li>-GPs Vaisala</li> <li>-1 ship in 2009</li> <li>-mobile AWS on XBT liner (cochin to Laccadive)</li> </ul>	<ul style="list-style-type: none"> <li>- 5 ISRO AWS (Laccadive Islands)</li> <li>- 5 ISRO AWS (Andaman &amp; Nicobar Islands)</li> </ul>

## Instruments available and planned for MT \_validation in India

Sensor	Parameter	Organization	Instruments available	Instruments Planned
MADRAS <b>1740 Km</b>	TWV	NARL CESS NCAOR NIO SHAR IMD,IISc	Sun Photometer, GPS Sonde Micro Rain radar  GPS Vaisala DWR GPS Sonde, DWR	Cloud Radar, Radiometer Sun Photometer Micro Rain Radar
	CLW	NARL, CESS NCAOR NIO SHAR, IMD, IIT (K)	Liquid Water content Probe	
	WS Ocean surface	NARL CESS NCAOR NIO SHAR, IMD, NIOT	AWS onboard ship AWS along XBT liner	
	Rain Rate	NARL CESS NCAOR NIO SHAR,IISc IMD,ISRO, TRITON	Disdrometer, Rainguage, AWS Disdrometer, MRR AWS AWS Rainguage, Surface Obs AWS(110)	4 Disdrometer, 10 AWS 4 AWS MRR
SAPHIR <b>1700 Km</b>	Humidity Profile Land >2km	NARL CESS NCAOR NIO,IISc SHAR, IMD	GPS Sonde GPS Sonde, Radiosonde	GPS Vaisala
SCARAB <b>2216 Km</b>	SW, LW Radiation	ISRO	GERB-Meteo, , ScRaB (Russian), CERES-Aqua	

## **Instruments at the Cal-val site in Kavarati in Lakshwadeep for MT validation**

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- At the Cal/Val site, there are two data buoys deployed 30 km off Kavarati
- One of the Buoy contains met/ocean sensors other surface met observations (surface wind, humidity etc.).
- Sun-photometer installed in the Kavarati lab.
- Micro Rain Radar & Disdrometer (Planned)

# Instruments installed for AMMA

Vaisala GPS radiosondes, temperature and relative humidity sensors, data loggers, Eppley/ Kipp & Zonen radiation instruments can be utilized for validation.

Instruments - very relevant to MT Cal–Val campaign is the microwave radiometer, Operates in the frequency range 23 GHz to 183 GHz.

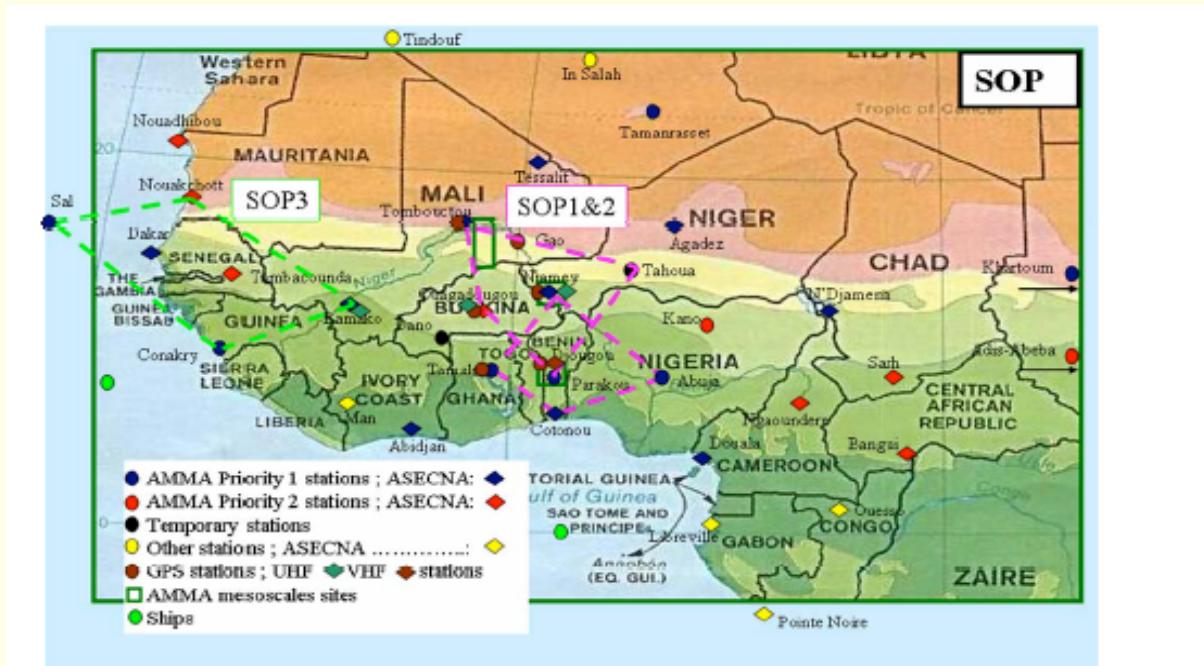


Fig. 2: Locations, priorities, quadrilaterals (flux arrays), GPS, UHF/VHF profiler and the mesoscale sites of AMMA international during SOP 2006

**For sampling cloud properties including cloud liquid water profiles at different locations. Aircrafts with well-instrumented sensors for temperature, humidity, wind, liquid water (concentration and size spectrum) and aerosol measurements can be used.**

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**Land based network will continue till year 2010.**

**The RS network set up will continue till the year 2010.**

**Rain gauge network will remain till 2010**

**Radars and profilers used during SOPs will be dismantled.**

**It will be useful to have radar and aircraft data too.**

**These data /facilities are essential for MT cal-val purpose**

## **Tentative Planning - Ship Cruises over AS , Equatorial Indian Ocean and BB M T validation:**

The primary parameters from MT to be validated are: Integrated water vapor, humidity profile, cloud liquid water content, wind speed, precipitation, short wave and Long wave radiation.

### **Observation requirement:**

Key to the mission is the repetitively of measurement in tropics.

**Limitation of Swath of MADRAS (Microwave Imager): 1700 km**

**SAPHIR & ScRAB : 2300 km**

**No of times of observation: 3.5 visibilities per day of the zone (22 N and 22 S)**

**5 visibilities per day of the zone (13 N and 13 S)**

### **Ship Cruises**

**In-situ data to be collected over research vessels like Sagar Kanya (DOD)**

**1. Time Period : Jan - 2010 (Region : Arabian Sea & Indian Ocean)**

**Parameters: Surface Met. Parameters, AWS data, G.P.S Radiosonde, rainfall.**

**2. Time Period : 10 July 2010 – 10 Aug. 2010**

**(Region : Bay of Bengal & Indian Ocean)**

**3. Time Period : 10 Jan 2011 - 10 Feb.2011**

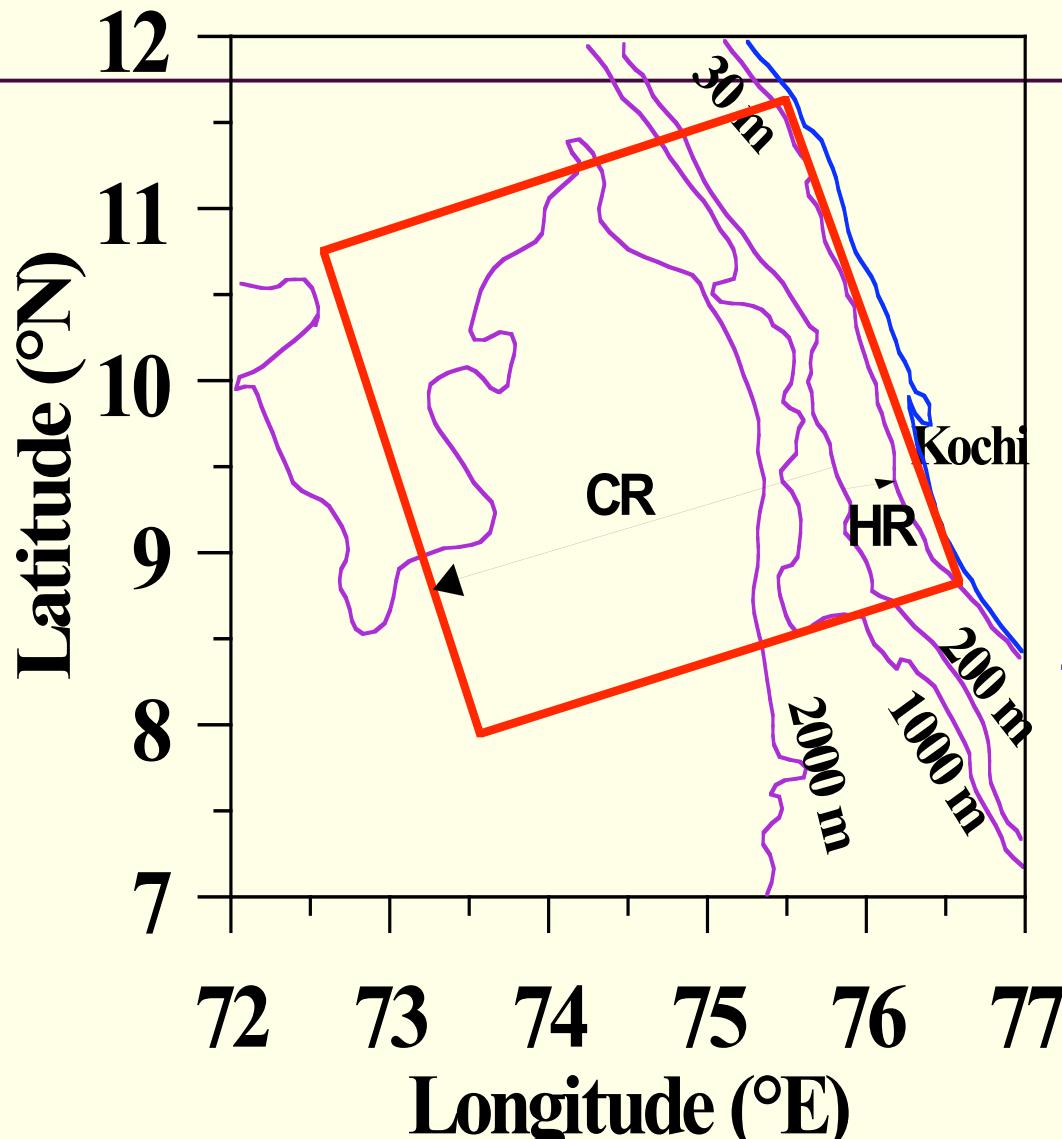
**(Region : Bay of Bengal & Indian Ocean)**

**4. Time Period : 10 July 2011 - 10 Aug.2011**

**(Region : Arabian Sea & Indian Ocean)**



# Experimental Programs: Off Kochi



HR : High Resolution  
(3 NM intervals)

CR : Coarse Resolution  
(15 NM intervals)

Spatial: Monthly

Time series:  
Seasonal

**THANK YOU**

# Indian Missions : Current & Future

**Kalpana-1**

**2002**



**CMV, OLR, Rainfall**

**INSAT-2E/3A**

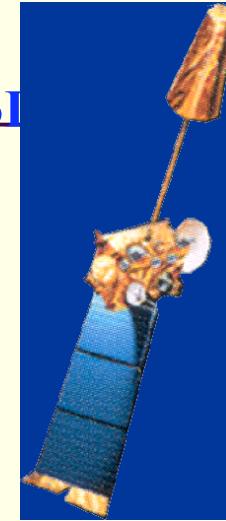
**(1999/2003)**



**CMV, OLR, Rainfall  
Aerosol**

**INSAT-3I**

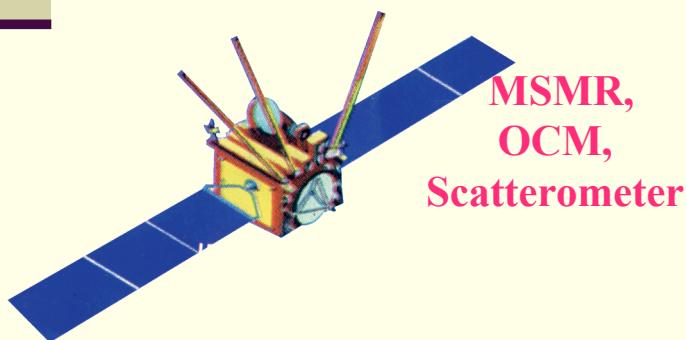
**(2008)**



**6-Ch VHRR  
R Sounder**

**SST, CMV, OLR, Rainfall,  
T, h Profile**

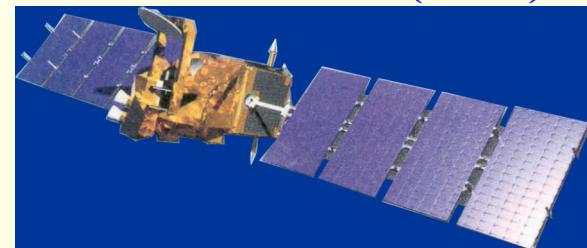
**OCEANSAT-1/2**  
**(1999/2008)**



**MSMR,  
OCM,  
Scatterometer**

**Vector Winds  
Aerosol**

**MEGHA-TROPIQUES**  
**(2009)**



**MW Imager,  
WV Sounder,  
ScaRaB**

**SS Wind, TWV, Rainfall  
T, h Profile,  
Radiation Budget**



# INSAT - 3D

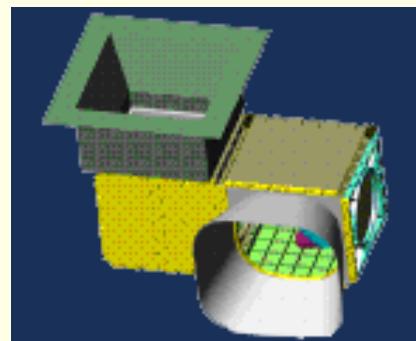
Improved Understanding of Mesoscale Systems

## 6 Channel IMAGER

- **Spectral Bands (μm)**
  - Visible : 0.55 - 0.75
  - Short Wave Infra Red : 1.55 - 1.70
  - Mid Wave Infra Red : 3.80 - 4.00
  - Water Vapour : 6.50 - 7.00
  - Thermal Infra Red – 1 : 10.2 - 11.3
  - Thermal Infra Red – 2 : 11.5 - 12.5
- **Resolution** : 1 km for Vis, SWIR  
4 km for MIR, TIR  
8 km for WV

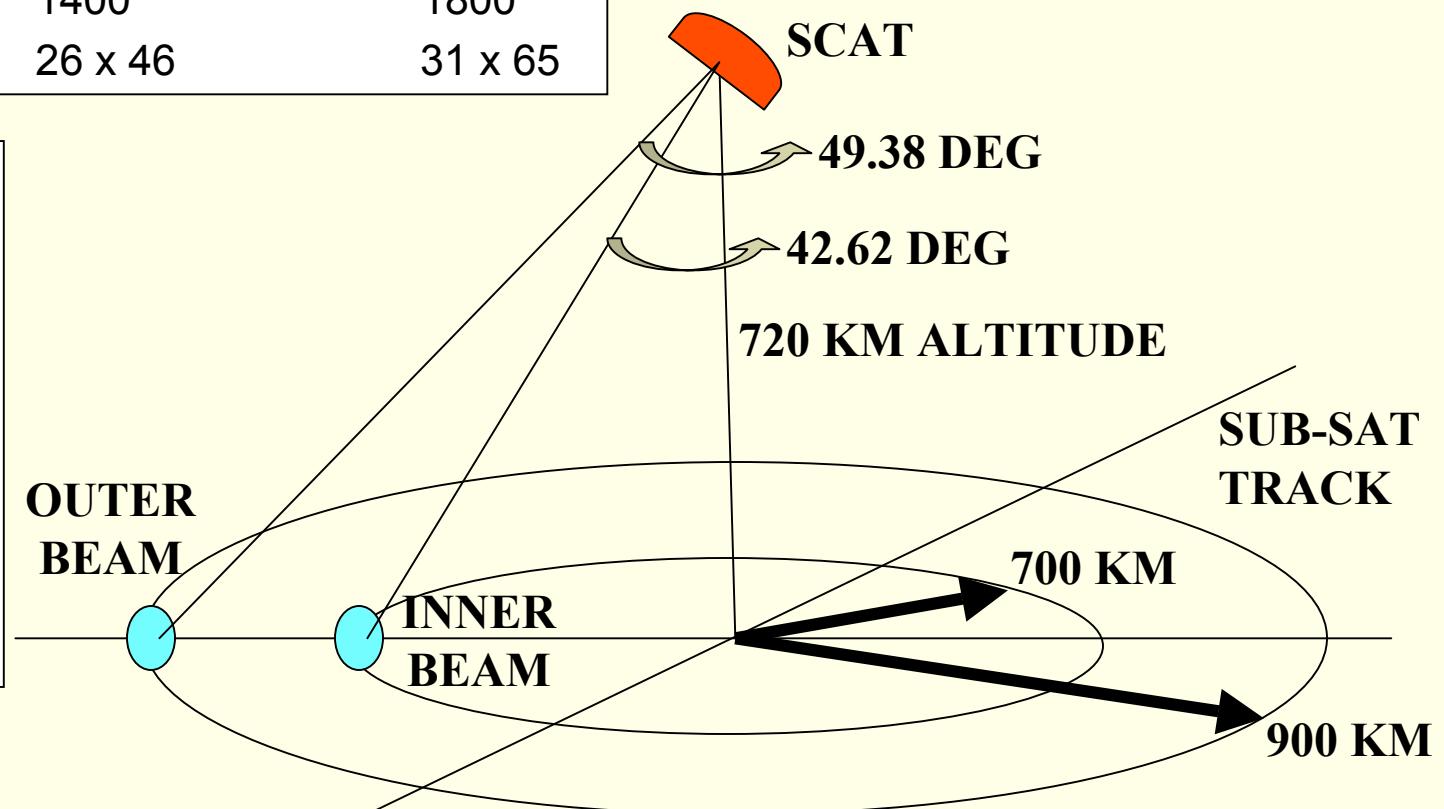
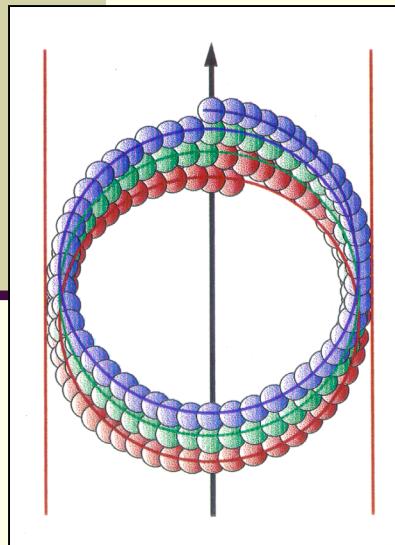
## 19 Channel SOUNDER

- **Spectral Bands (μm)**
  - Short Wave Infra Red : Six bands
  - Mid Wave Infra Red : Five Bands
  - Long Wave Infra Red : Seven Bands
  - Visible : One Band
- **Resolution (km)** : 10 X 10 for all bands
- **No of simultaneous sounding per band** : Four



## OCEANSAT-2 SCATTEROMETER

ALTITUDE	720 KM
FREQUENCY	Ku-BAND (13.5 GHz)
CONFIG.	PENCIL-BEAM
	INNER                    OUTER
INC. ANG. (DEG)	50.16                    57.27
POLARIZATION	HH                        VV
SWATH (KM)	1400                    1800
IFOV (KM)	26 x 46                31 x 65



# INSAT-3A & Kalpana-1

(2003)

(2002)

## Location

: INSAT 3A : 93.5°E

Kalpana-1 : 74°E



## Payload

: (i) VHRR & CCD camera in INSAT 3A  
(ii) VHRR in Kalpana-1

- 

### VHRR Bands ( $\mu\text{m}$ )

- Visible : 0.55 – 0.75
- Water vapour : 5.70 – 7.10
- Thermal Infra Red : 10.5 – 12.5

- 

Resolution (km) : 2 X 2 for Visible  
8 X 8 for WV & TIR

- 

### CCD Camera Bands ( $\mu\text{m}$ )

- Visible : 0.62 – 0.68
- Near Infra Red : 0.77 – 0.86
- Short Wave Infra Red : 1.55 – 1.69

- 

Resolution (km) : 1 X 1 for all bands



No.	Parameters	Input Channels
1	<i>Outgoing Longwave Radiation (OLR)</i>	TIR-1, TIR -2, WV
2	<i>Quantitative Precipitation Estimation (QPE)</i>	TIR-1, TIR- 2
3	<i>Sea Surface Temperature (SST)</i>	SWIR,TIR – 1, TIR - 2, MIR
4	<i>Snow cover</i>	VIS, SWIR, TIR – 1, TIR –2
5	<i>Snow depth</i>	VIS, SWIR, TIR – 1, TIR –2
6	<i>Fire</i>	MIR, TIR -1
7	<i>Smoke</i>	VIS, TIR –1, TIR –2, MIR
8	<i>Aerosol</i>	VIS, TIR –1, TIR -2
9	<i>Cloud Motion Vector (AMV)</i>	TIR-1, TIR –2, VIS
10	<i>Water Vapour wind (WVW)</i>	TIR-1,TIR –2, WV
11	<i>Upper Tropospheric Humidity(UTH)</i>	TIR-1,TIR –2, WV
12	<i>Temperature, Humidity profile and Total Ozone</i>	Sounder all Channels
13	<i>Value added parameters from sounder products</i>	Sounder products
14	<i>Fog</i>	SWIR, MIR, TIR-1,2
15	<i>Normalized difference vegetation Index</i>	CCD
16	<i>Flash Flood Analyser (FFA)</i>	TIR – 1, TIR –2, VIS

- NARL-SHAR-Chennai Triangle will be used as one of the intensive validation sites for MT parameters.
- CTCZ sites in Mahanadhi Basin for MT Validation.

# **Inter-Comparison Of Megha-Tropiques Derived Parameters With Other Satellites**

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**Geophysical parameters retrieved from MT will be inter-compared  
with the available concurrent satellites:**

<b>Wind Speed</b>	<b>SSM/I, TRMM, Oceansat - 2</b>
<b>Water vapor</b>	<b>SSM/I, TRMM/TMI, ENVISATI, TERRA/AQUA, INSAT-3D</b>
<b>Liquid water</b>	<b>SSM/I, TRMM/TMI, INSAT, ENVISAT I, METOP</b>
<b>Rainfall</b>	<b>SSM/I, TRMM/TMI, INSAT, NOAA/ATOVS, AVHRR</b>
<b>Radiation</b>	<b>ScRaB (Russian), GERB</b>

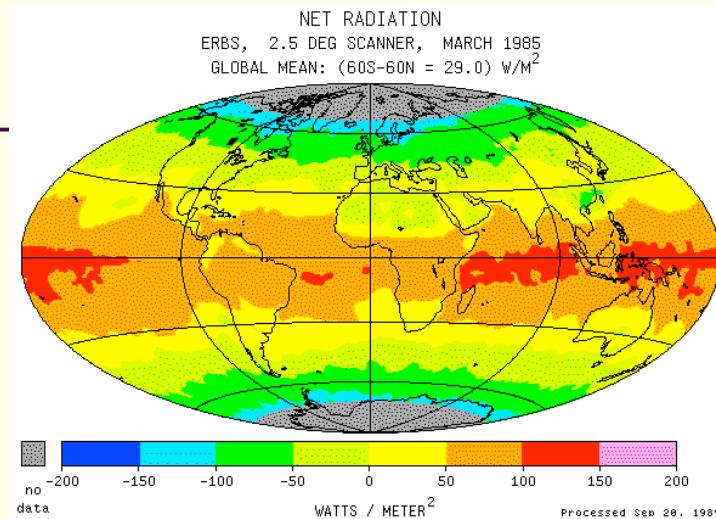
## **Comparison Of Satellite Derived Products With Model Analysis**

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- i) The MT data and NCMRWF/ECMWF- model analysis will be compared. For this, MT data of wind speed (V), and Total precipitable water vapour (TPW) and other geophysical parameters will be averaged in space and time.
  
- ii) Comparison has to be done first over areas or basins where the model analysis gives good results with in-situ.

- Satellite microwave radiometers require precisely calibrated brightness temperatures for the accurate retrieval of geophysical parameters.
- Radiometers are calibrated on-orbit by comparing the measured brightness temperatures to on-Earth targets whose brightness temperature is known or can be accurately modeled
- Validation of the initial algorithm and the geophysical parameters require surface observations over a range of surface conditions and seasons.

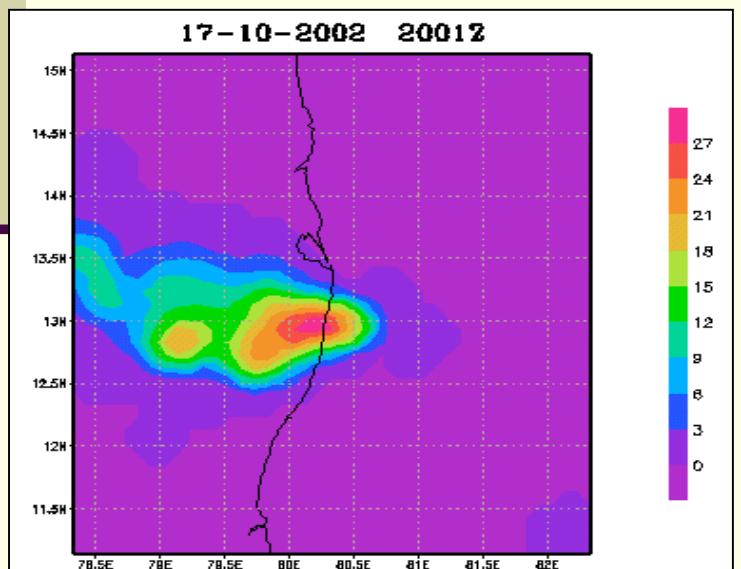
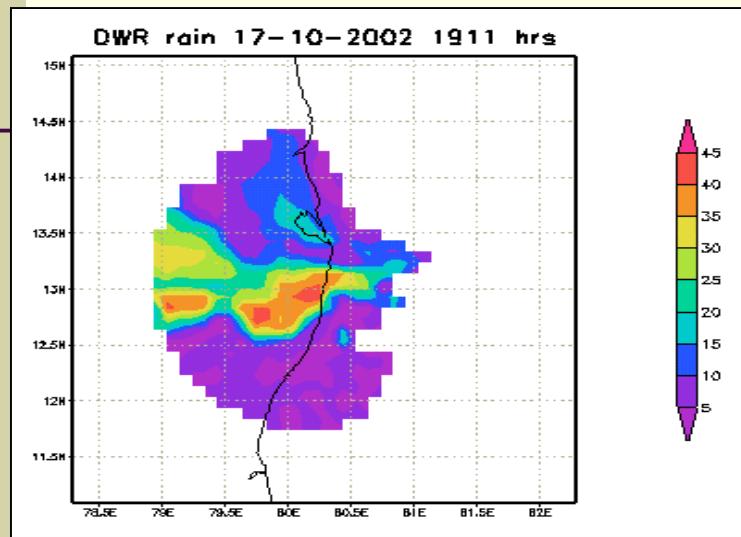
## 1. Objectives of ScaRaB/MT & Characteristics



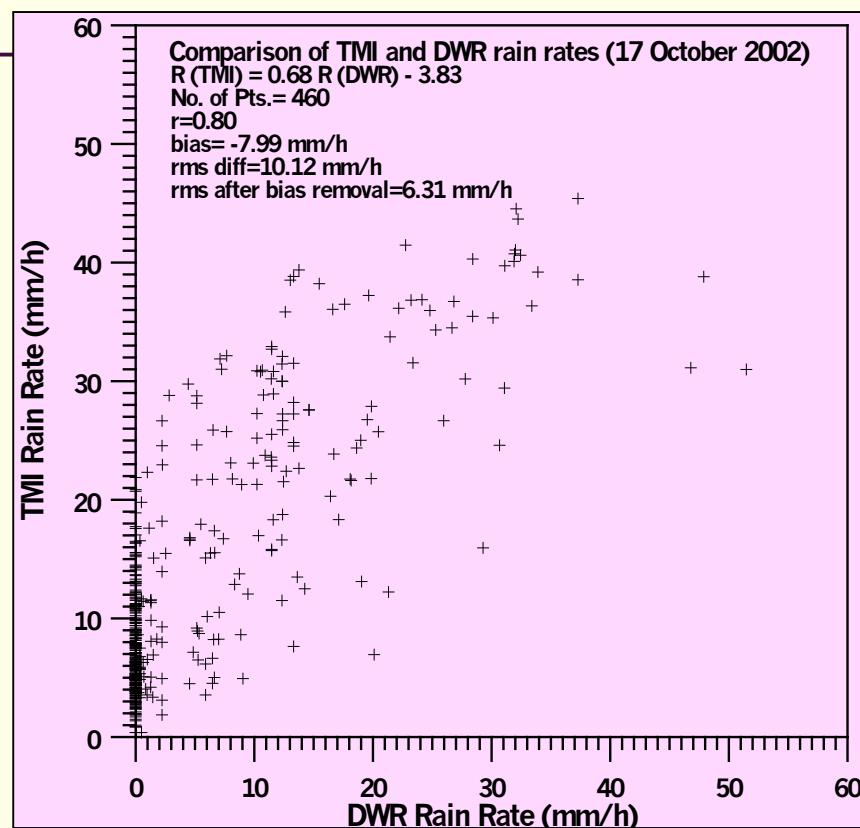
### Radiation Flux Accuracy

- ⌘  $20\text{Wm}^{-2}$  accuracy is given by the instantaneous fluxes using ERBE-like algorithm,  $10 \text{ Wm}^{-2}$  will be sought.
- ⌘ Mean accuracy of  $5 \text{ Wm}^{-2}$  is sought for the regional monthly means, and up to  $2 \text{ Wm}^{-2}$  for zonal monthly means]

## VALIDATIONS: TRMM VS. DWR RAINFALL



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NASA-GPR OF RAINFALL PRODUCT